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EFFECTS OF OVERSTORY REMOVAL ON ADVANCE REGENERATION
OF SELECTIVELY LOGGED SECOND-GROWTH STANDS

A REPORT TO JDSF ON CONTRACT NO.1CA63827

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MARCH 17,1989

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EFFECTS OF OVERSTORY REMOVAL ON ADVANCE REGENERATION OF SELECTIVELY LOGGED SECOND-GROWTH STANDS

(ab I-1)

INTRODUCTION

Impetus for this study is the ongoing harvest cutting of second-growth redwood/fir stands that were selectively logged during the past 20 years. These harvest cuts are often termed "overstory removal", a process not well defined. Here the context is the final harvest of second-growth stands from which 40 to 70 percent of the volume was cut 20 years ago. In this study no trees smaller than 15 inches DBH were cut. The reason for leaving these small trees is primarily ecomonic. The advance regeneration under the overstory is part of the basis of the next stand. An important objective of this study is to evaluate the importance of small trees and advance regeneration in the progress of new stands. The use of selective logging for management of coastal stands has important silvical implications in the development of the next young-growth forest. Our interest is to determine how advance regeneration under a selective system overstory can survive a harvest cut to help restock with the desired species.

The value of advance regeneration in tree or group selection silvicultural systems has been considered by a wide range of research on many species. Most of these studies refer to an uneven-aged management system where stands composed of several different age classes are developed. Success of this system depends on the biological capacity of the desired species to reproduce, become established, and grow well under the overstory left after each cutting. The condition in this study is final harvest of the overstory left after a single entry 20 years earlier. Now we consider development of a quasi even-aged stand with components of small residual second-growth trees, advance regeneration, and new regeneration that starts after final harvest. Managers will have to deal with new stands with at least two age classes about 20 years apart. McCaughey and Schmidt (1982) make the point in their study that knowing when to leave and when to destroy advance regeneration is important in the scheme of stand management.

Redwood's ability to sprout creates problems and opportunities unique to this commercial species. Leaving the advance sprouts on the second-growth stumps may inhibit subsequent sprouting and sprout growth on new stumps created by this latest logging. It becomes a balance of determining whether stand development will be better served by leaving the advance sprouts or felling them so that the new stumps and other redwood stumps from the recently cut second-growth will create a uniform age class of sprouts.

Four specific objectives for the study were set out in the proposal to the California Department of Forestry. These objects are:

1. How much advance regeneration was established, and then survived the logging of the overstory?
2. Will total removal of the understory regeneration affect the rate of stand recovery?
3. ~~Is~~ Are there differential rates of growth of the two levels of regeneration in the new stand?
4. Does leaving the advance redwood regeneration affect the rate of redwood sprout growth of new stumps?

Objectives 2:3,and 4 require a long term involvement with these sample plots. Only objective 1 is capable of being dealt with now in this report. These objectives are examined on six plots established, then measured before and after logging. After evaluation of ~~the~~ regeneration surviving ~~the~~ logging, the plots will be split, with half of the area having all advance regeneration cut. When this study was proposed, ~~At the time of the study proposal~~ it was not known that only stems larger than 15 inches DBH would be harvested; however, this does not affect the study's thrust. The study will also consider the value of the small residual second-growth stems to the regrowth of the new stand.

METHODS

This report deals with three phases of work. First the measurement and description of the overstory and understory prior to logging. The second phase is the measurement of the stands after logging and describing the loss of ~~the~~ advance regeneration. The final phase is the removal of all advance regeneration and residual overstory stems on half of each of six plots. After 5-10 years the plots will be remeasured to determine the amount of and contribution of residual advance and new regeneration to the new stand.

The overstory stand.

Stands in the Middle Fork of Caspar Creek on the Jackson Demonstration State Forest (JDSF) were chosen for overstory removal in 1987. A 41-acre block in Sections 10 and 11 of T 17N, R17W between Road 640 and the North Fork of Caspar Creek (Figure 1.) was selected for this study. The stand is on the south side of the creek and has a northern aspect. Slopes of the southern portion of this block were suited for tractor operations; the northern part closer to the creek are steep and more suited to cable logging. The entire block showed evidence of extensive tractor work from the 1967 selection logging. Locations of six .4 acre sample plots in the 20 acre segment of the block are shown in Figure 1. The southwest corner of each plot was determined by two random coordinates selected so that the plots do not overlap and remained within

Figure 1. Location of Block 8 of the Middle Fork of Caspar Creek 1987 overstory harvest cutting. The six .4 acre sample plots were distributed at random in the 20 acre unit of the block.

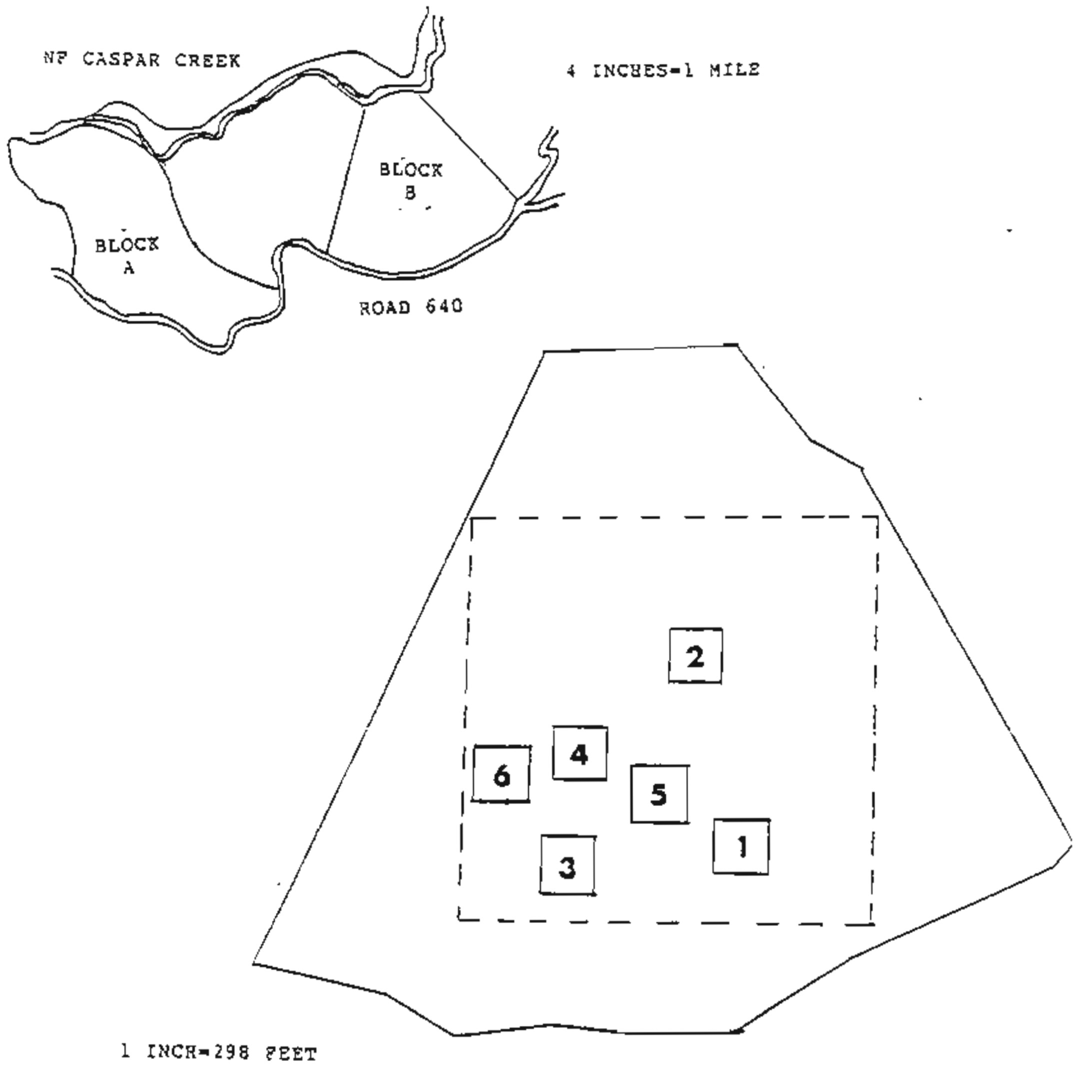

Table 1. Summary of the per acre stand values prior to the 1987 logging of the Middle Fork Caspar Creek Block B of the 1987 overstory removal harvest. Results are based on sampling of conifers of six random .4 acre plots.

Plot	Trees > 4.5 inches: Trees	Basal area	Ave. dia.	Cubic vol.	Trees >10.5 inches: Trees	Basal area	Scrib. vol.
		(sqft)	(in)	(cuft)		(sqft)	(bdft)
1	120.0	204.3	17.7	7823.3	55.0	185.6	46223.4
2	125.0	186.3	16.5	7066.6	62.5	171.5	41254.9
3	155.0	297.6	18.8	11520.7	112.5	286.4	69118.3
4	137.5	196.7	16.2	7382.7	72.5	180.1	42711.9
5	147.5	263.4	18.1	10030.5	102.5	252.8	59955.1
6	172.5	327.1	18.6	13550.2	110.0	307.3	78488.6
Ave.	142.9	245.9	17.8	9562.0	85.8	230.6	57137.2
S.D.	19.6	58.8		2605.6	25.5	59.3	16906.1
%Rwd	92.4	92.1		89.0			88.4

the boundaries of the square 20 acre segment.

The second-growth stand was selectively logged in 1967, and this logging removed most of the conifers other than redwood. The stand logged in 1967 was primarily redwood with a few large Douglas-fir. The stand overstory in 1987 is described by the six plots shown in Table 1. Stems larger than 4.5 inches DBH had 92 percent redwood basal area and 89 percent redwood trees. Plots had an average of 47 conifer stumps with 195 square feet basal area per acre; 73 percent are redwood. Average age, from stumps of trees measured for total height, in 1987 was 90.0 years. The site index of the redwood was estimated to be 160. The original second-growth stand was primarily redwood and the tree selection logging further concentrated the redwood portion.

Each live stem, second-growth stump, and old-growth stump within each plot was mapped. The stem maps show the location of the redwood stumps and stems that are a crucial part of the stand regrowth. Following the harvest cut, which took only stems over the 15 inches, there is left for the nucleus of the new stand an average of about 80 trees per acre with a basal area of 33.5 square feet. The diameter distribution of stems larger than 4.5 inches DBH prior to this harvest is shown in Table 2. Most stems smaller than 10 inches DBH are redwood sprouts established on stumps from the selection cut. Many of the second-growth trees left by this harvest cut are poor quality intermediate and suppressed trees with limited crowns. An average of 51 second-growth stumps per acre were found in the six plots. Approximately 50 percent of the stumps were over 20 inches in diameter. Size distribution of the stumps of the selection logged second-growth stand are shown in Table 3. Except for the 22.5/acre four-inch stumps in plot 3 there would be very uniform numbers of stumps in these plots. The second-growth redwood stumps are the source of the most vital advance redwood regeneration found in the plots.

Total height of 28 redwood, three Douglas-fir, and three grand fir were measured across a range of stem diameters. These heights and diameters at breast height were used to compute tree volumes from which local volume tables for three species were developed. Stem volumes were computed from Wensel and Krumland (1976) equations to a 6-inch top diameter for cubic feet and an 8-inch limit for Scribners board-feet. Equations for computation of the stand volumes are as follows:

Redwood

cubic foot = -3.472 + .2172 X dia X dia

board foot = -72.594 + 1.4519 X dia X dia

Douglas-fir

cubic foot = -5.064 + .3165 X dia X dia

Table 2. Diameter distributions of the overstory prior to the harvest of the stand in 1987 in Block B of the Middle Fork Casper Creek logging. Distributions of the stems in six .4 acre plots include all conifer and hardwood trees larger than 4.5 inches DBH.

	Plot							
Diameter	1	2	3	4	5	6	Ave.	S.D.
(in.)	(stems/acre)							
5	22.5	22.5	15.0	20.0	17.5	7.5	17.50	5.70
6	10.0	12.5	10.0	17.5	15.0	7.5	12.08	3.68
7	5.0	17.5	2.5	10.0	2.5	15.0	8.75	6.47
8	5.0	10.0	7.5	2.5	2.5	17.5	7.50	5.70
9	10.0	5.0	5.0	7.5	2.5	5.0	5.83	2.58
10	12.5	0	5.0	7.5	5.0	10.0	6.67	4.38
11	2.5	7.5	5.0	5.0	5.0	2.5	4.58	1.88
12	2.5	5.0	2.5	2.5	5.0	5.0	3.75	1.37
13	0	7.5	7.5	5.0	12.5	10.0	7.08	4.31
14	10.0	5.0	7.5	5.0	7.5	0	5.83	3.42
15	5.0	0	10.0	10.0	7.5	2.5	5.83	4.08
16	0	2.5	5.0	2.5	7.5	7.5	4.17	3.03
17	2.5	2.5	5.0	0	5.0	12.5	4.58	4.31
18	0	2.5	7.5	7.5	0	12.5	5.0	5.00
19	0	2.5	2.5	2.5	12.5	2.5	3.75	4.40
20	5.0	2.5	5.0	7.5	2.5	5.0	4.58	1.88
21	5.0	0	7.5	0	0	7.5	3.33	3.76
22	0	2.5	5.0	2.5	0	7.5	2.92	2.92
23	0	0	2.5	2.5	2.5	5.0	2.08	1.88
24	0	5.0	7.5	2.5	7.5	0	3.75	3.45
25	2.5	7.5	12.5	2.5	2.5	2.5	5.00	4.18
26	0	2.5	2.5	2.5	7.5	0	2.50	2.74
27	0	0	2.5	2.5	5.0	5.0	2.50	2.24
28	0	0	2.5	0	0	2.5	.83	1.29
29	2.5	0	2.5	0	2.5	0	1.25	1.37
30	2.5	2.5	2.5	0	2.5	0	1.67	1.29
31	0	0	2.5	0	2.5	2.5	1.25	1.37
32	0	2.5	0	2.5	2.5	0	1.25	1.37
33	5.0	2.5	0	2.5	2.5	2.5	2.50	1.58
34	0	0	2.5	0	0	5.0	1.25	2.09
35	5.0	0	0	0	0	5.0	1.67	2.58
36	0	0	0	2.5	0	2.5	.83	1.29
37	2.5	0	0	0	0	0	.42	1.02
38	0	2.5	0	2.5	0	0	.83	1.29
39	0	0	0	0	2.5	0	.42	1.02
40	0	2.5	0	0	0	0	.42	1.02
>40	2.5	0	2.5	0	0	2.5	1.25	1.37
Total	120.0	135.0	157.5	137.5	150.0	172.5	145.4	18.5

Table 3. Number of second-growth stumps from the 1967 selection logging. Data measured in the 1987 prior to the overstory removal of Block B in the Middle Fork of Caspar Creek.

	Plot							
Dia	1	2	3	4	5	6	Total	SD
(in.)	(no. stumps/acre)							
4	0	0	22.5	0	0	5.0	4.6	9.0
5	0	0	2.5	0	0	0	.4	1.0
6	5.0	0	2.5	2.5	0	5.0	2.5	2.2
7	0	0	0	0	0	0	0	0
8	0	2.5	0	0	0	0	.4	1.0
9	0	0	0	0	0	0	0	0
10	2.5	0	0	2.5	0	0	.8	1.3
11	0	0	0	0	0	0	0	0
12	5.0	5.0	2.5	7.5	2.5	0	3.8	2.6
13	0	0	2.5	2.5	0	0	.8	1.3
14	2.5	0	5.0	0	2.5	2.5	2.1	1.9
15	2.5	2.5	2.5	2.5	0	2.5	2.1	1.0
16	0	0	0	0	5.0	2.5	1.2	2.1
17	0	0	0	0	2.5	0	.4	1.0
18	2.5	2.5	5.0	5.0	7.5	2.5	4.2	2.0
19	0	0	0	0	0	0	0	0
20	5.0	5.0	5.0	0	2.5	0	2.9	2.7
21	0	0	0	0	0	0	0	0
22	0	2.5	0	2.5	0	0	.8	1.3
23	0	0	0	0	0	0	0	0
24	12.5	2.5	5.0	2.5	2.5	2.5	4.6	4.0
25	2.5	0	5.0	2.5	5.0	0	2.5	2.2
26	0	0	2.5	2.5	0	0	.8	1.3
27	2.5	0	0	0	0	0	.4	1.0
28	0	0	0	2.5	0	0	.4	1.0
29	0	0	0	2.5	0	0	.4	1.0
30	0	0	10.0	0	2.5	0	2.1	4.0
31	0	0	0	0	0	0	0	0
32	0	2.5	0	0	0	0	.4	1.0
33	0	0	0	0	2.5	0	.4	1.0
34	0	0	0	0	0	0	0	0
35	0	2.5	2.5	0	5.0	0	1.7	2.0
36	0	5.0	0	2.5	0	2.5	1.7	2.0
37	0	0	0	0	0	0	0	0
38	0	0	0	0	5.0	0	.8	2.0
39	0	0	0	0	0	0	0	0
40	2.5	2.5	2.5	7.5	5.0	7.5	4.6	2.5
>40	2.5	2.5	0	0	7.5	0	2.9	2.9
total	47.5	37.5	77.5	47.5	57.5	37.5	50.8	15.1

board foot =-117.096 + 2.3419 X dia X dia

Grand fir and hemlock
cubic foot = -3.7936 + .2372 X dia X dia
board foot =-75.196 + 1.509 X dia X dia

Computed stand cubic foot volumes for trees >4.5 inches, and the Scribner volumes for those >10.5 inches DBH are shown in Table 1. Actual volume cut is less than that shown since only trees larger than 15 inches were cut. It is estimated that there were about 3400 board feet in the 11 to 14 inch diameter classes.

Understory regeneration sampling

Assessment of the advance regeneration understory of this selectively logged stand was done with ten randomly located nested 1-and 4-milacre quadrats in each plot. The two nested circular quadrats used the same center point which was selected by a random x and y coordinate inside the plot boundaries. The 1-milacre quadrat (.001 acre) sampled only stems shorter than 4.5 feet. The larger 4-milacre (.004 acre) sampled trees taller than 4.5 feet but less than 4.5 inches DBH. A total of sixty sets of quadrats are used to describe the regeneration of trees in the 20 acre unit of Block 8. Regeneration sampling of this study is a two-stage sampling scheme. The primary sample selection is the six plots and the second stage the ten random quadrats within each plot. This form of sampling loses some precision but has an advantage of lower costs than a completely random sample in the 20 acre unit. In this study two independent sets of 60 random plots were established for the pre- and post-logging understory regeneration in the six plots. Attempting to locate and install permanent sample quadrats to remeasure after logging is a difficult task. Being unable to find and remeasure all of the same quadrats results in the statistical problem of dealing with missing data.

Treatment of plots

The final work in establishment of this study was the removal of advance regeneration and the small second-growth residuals from one-half of each plot. This work was completed during the fall of 1988.

Results and discussion CAPS

Regeneration results of the ten prelogging quadrats in the six plots are summarized in Table 4, with the size and species distribution in Table 5. Prior to logging four of 60 quadrats had no regeneration, and were 93.3 +/-8.2 percent stocked. The estimate of advance conifers regeneration <4.5 inches DBH averaged 4175 +/-1781.6 stems per acre in the 20 acre unit. The standard error of the mean estimated for a

Table 4. Pre-logging regeneration of ten sample points in the six .4 acre plots of the Middle Fork Caspar Creek overstory removal. The results are from milacre quadrats for stems less than 4.5 feet tall, and four milacre quadrats for stems over 4.5 feet tall but less than 4.5 inches DBH.

	Plot number					
Quadrat	1	2	3	4	5	6
		(stems per acre)				
1	3500	1250	250	23250	3750	2000
2	0	7250	250	2750	1000	6250
3	5000	6500	4750	2750	250	1250
4	8500	11500	4500	2000	1750	6750
5	0	0	8750	3500	2250	7000
6	7500	2750	2000	7750	2500	9000
7	1500	1750	3250	3000	3500	1750
8	500	750	2000	5000	0	8000
9	1500	8500	2750	15250	5750	6000
10	2250	7000	500	5500	2500	2250
Ave.	3025	4725	2875	7075	2325	5025
S.D.	3056	3910	2617	6898	1732	2902

Table 5. Average per acre regeneration by species and size classes before the logging of six plots in block B of the Middlefork of Caspar Creek 1987 overstory removal. Results are from surveys of 10 nested milacre and 4-milacre random quadrats in each plot. Stems less than 4.5 feet tall on milacre quadrats, stems larger than 4.5 feet on the 4-milacre quadrats.

Size	Redwood	Douglas-fir	Grand fir	other	total
(ft)		(stems/acre)			
<1'	16.7	250.0	16.7	333.3	616.7
1-2'	100.0	316.7	166.7	166.7	750.0
2-3'	33.3	333.3	83.3	66.7	516.7
3-4.5'	50.0	100.0	233.3	216.7	600.0
(in)					
<.5"	200.0	195.8	179.2	237.5	808.3
1"	150.0	116.7	129.2	145.8	541.7
2"	145.8	33.3	37.5	16.7	233.3
3"	37.5	4.2	0	0	45.7
4"	54.2	0	4.2	4.2	62.6
total	787.5	1350.0	850.0	1187.5	4175.0
	19.9%	32.3%	20.4%	28.4%	

Table 6. Conifer regeneration that survived the overstory removal in six plots of the Middle Fork Caspar Creek study. Per acre data from 10 nested quadrats in six .4 acre plots.

	Plot number					
Quadrat	1	2	3	4	5	6
1	2000	1250	0	0	0	250
2	250	3000	0	5500	0	2250
3	0	500	4750	1500	1500	0
4	0	0	250	0	500	1000
5	0	500	4750	750	1000	250
6	0	0	4250	5000	3250	0
7	0	250	0	4250	2500	1000
8	1000	0	3250	0	500	0
9	0	2500	0	3750	250	0
10	1500	2250	1000	1750	1750	1000
Ave.	475	1025	1825	2250	1125	575
S.D.	749	1151	2148	2176	1107	736

Table 7. Species and size distribution of the post logging survey of the Middle Fork of Caspar Creek overstory harvest.

Size	Redwood	Douglas-fir	Grand fir	Other	Total
(ft)		(stems/acre)			
<1'	0	50.0	0	33.3	83.3
1-2'	0	66.7	33.3	66.7	166.7
2-3'	33.3	50.0	0	16.7	100.0
3-4.5'	16.7	66.7	16.7	16.7	116.7
(in.)					
<.5	95.8	95.8	62.5	75.0	329.2
1"	91.7	45.8	41.7	41.7	220.8
2"	70.8	25.0	8.3	4.2	108.3
3"	41.7	0	0	4.2	45.9
4"	37.5	0	0	4.2	41.7
total	387.5	400.0	162.5	262.5	1212.5
	31.9%	32.9%	13.4%	21.6%	
survival	49.2%	29.6%	19.1%	22.1%	29.0%

two-stage sampling plan (Freese, 1962) was computed to be 701.9 stems per acre. Analysis of variance (ANOVA) of the prelogged conifer regeneration indicated no significant difference between the averages of the six plots.

Source	D.F.	M.S.	F-level	F(.05)
between plots	5	31527500	2.086	2.38
within plots	54	15113889		
total	59			

Redwood regeneration in the quadrat sampling portion of the study only accounts for those new sprouts which were <4.5 inches DBH. Some new redwood sprouts exceed this diameter limit and were not included in this sampling. Still Table 5 indicates that redwood accounts for only 20 percent of the total amount of regeneration, but nearly 100 percent of that over 2.5 inches DBH. Overall the most desirable species, redwood and Douglas-fir, account for only slightly more than 50 percent of the total conifer regeneration before logging. Also shown in Table 5, Douglas-fir is the most frequent conifer under 4.5 feet tall but least frequent over 4.5 feet tall.

More than one-half of the Douglas-fir, grand fir, and hemlock seedlings were in dense mixed thickets on or adjacent to the skid trails of previous logging. The 14 most heavily stocked quadrats averaged about 17 stems in each of the nested samples, this computed an average of about 9800 whitewood stems per acre. Table 5 shows that 67 percent of the whitewood stems are less than 4.5 feet tall and the most susceptible to damage by logging. Most redwood stems are sprouts which are also clustered, but only one of 60 samples exceeds the rate of 5000 redwood/acre. The majority (75 percent) of redwood are sprouts over 4.5 feet tall that cluster about stumps which offer some protection from logging activity.

A similar study of understory regeneration 20 years after tree selection logging of second-growth redwood was reported in the Caspar Creek Cutting Trials (CCCT) (Lindquist, 1988). In this earlier work there were 4690 conifer stems per acre <4.5 inches DBH after logging an 85-year old stand. Redwood and Douglas-fir accounted for 9.2 percent of the total regeneration in the CCCT study.

In the summer of 1987 this block was logged, and the resurvey of surviving regeneration in the plots was made during the winter of 1987-88. For each plot a new set of ten random coordinates were chosen to locate the new samples. Results of this survey are summarized in Table 6, and the distribution by species and size in Table 7. The logging resulted in a loss of nearly 3000 conifer stems per acre. This post logging survey showed 1212.5 +/-699.2 conifer stems per acre with a standard error of estimate of 275.0 stems. Despite heavy loss of stems the number of stocked quadrats still average 63.3 +/-13.7 percent. ANOVA of the quadrat data of Table 4 indicates no significant difference between the average number of regeneration stems of the six plots after logging.

Source	D.F	M.S	F-level	F(.05)
Between plots	5	4889375	2.256	2.38
Within Plots	54	2167245		
Total	59			

The distribution of regeneration is considered uniform in the post-logging stand. Logging has had an uneven effect on how a species survived. Redwood and Douglas-fir following logging now are about 65 percent of the total number of conifers. Douglas-fir stayed about the same percent, redwood increased, while the other conifers dropped as a percent of the total. Almost half of the redwood survived the logging, but the other conifers had survival rates of 20 to 30 percent. Stems larger than 4.5 feet tall which were about 41 percent before logging are now 61.5 percent of the total regeneration <4.5 inches DBH. The small trees have been harder hit by the logging; 81.2 percent of the trees <4.5 feet have been destroyed. The number of survivors in the larger stem classes was not disturbed as severely the smaller classes.

While the number of stems per acre have dropped by nearly 75 percent there is still no significant difference between plots. There is indicated a uniform reduction in the advance regeneration by logging the plots. Maximum number of survivor stems in any quadrat is 5500/acre, this is only about 25 percent of the maximum quadrat stocking of the prelog survey. Most of the dense whitewood thickets found before logging have been reduced or taken out, the distribution of stems in the stocked plots is still uniform.

Logging resulted in a major change in the total number of stems in the advance regeneration regime. A comparison of the averages in the pre- and post-logging data with ANOVA indicated a highly significant difference between the two surveys. Using 60 quadrats in each survey as a single sample the following results clearly indicate the effect of logging on the advance regeneration.

Source	D.F.	M.S.	F-level	F(.05)
Between years	1	2.6329+08	27.87	3.92
Within years	118	.5104+06		
Total	119			

Conclusions CAPS

As this block recovers from the this final cut the next stand will develop from the combination of three components, residual second-growth trees, surviving advance understory stems, and new sprout growth on new stumps. It is difficult to predict how these components will interact under these competitive conditions. Most residual stems were suppressed or intermediates in the overstory canopy with very small thin crowns. Whether new crown growth develops on these trees enough to allow increased radial growth is questionable. The advance redwood sprouts that exceed 4.5 inches are a vital portion of the residual stems.

As a result of the two surveys of these plots some insight about the advance regeneration's character and how it can survive logging is now available for making judgements about it's relevance to future management. The effects of logging on the advance regeneration's ability to contribute to the creation of suitable new stands can only be determined after a period of time. It is clear that a great number of understory stems were established in the 20 years after selection logging. However, the species composition may not be management's ideal since nearly 50 percent of the initially established stems were either grand fir or hemlock. The resurvey revealed that enough stems survived the harvest cut so that the area is considered legally stocked even without the residual stems. Tractor logging the overstory on this block took out about 75 percent of the total original regeneration, but the percentage of redwood and Douglas-fir improved. The next influx of regeneration will be primarily redwood sprouts, since the 65 stems that were cut are nearly all ~~were~~ redwood. Other instances of heavy cutting of second-growth redwood show that nearly all stumps sprout vigorously.

New regeneration will have to face strong competetion from the residual stand. How much this new wave of trees will contribute will be a function of this competetion. Redwood sprout growth is perhaps the only component that will be a significant factor in this new regeneration. In specific areas the crowns of residual trees may close soon and restrain the establishment of new seedlings. Early crown closure will not seriously affect growth of the well established ~~stems of the~~ tolerant hemlock now in the stand. It will be interesting to follow the hemlock component of these plots to see if it becomes a serious species in the stand; hemlock was not a major component in the second-growth stand structure. ?

significant ?
dominant ?
primary ?

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